## 19.0 JOINT EXCURSION SYSTEM (JES)

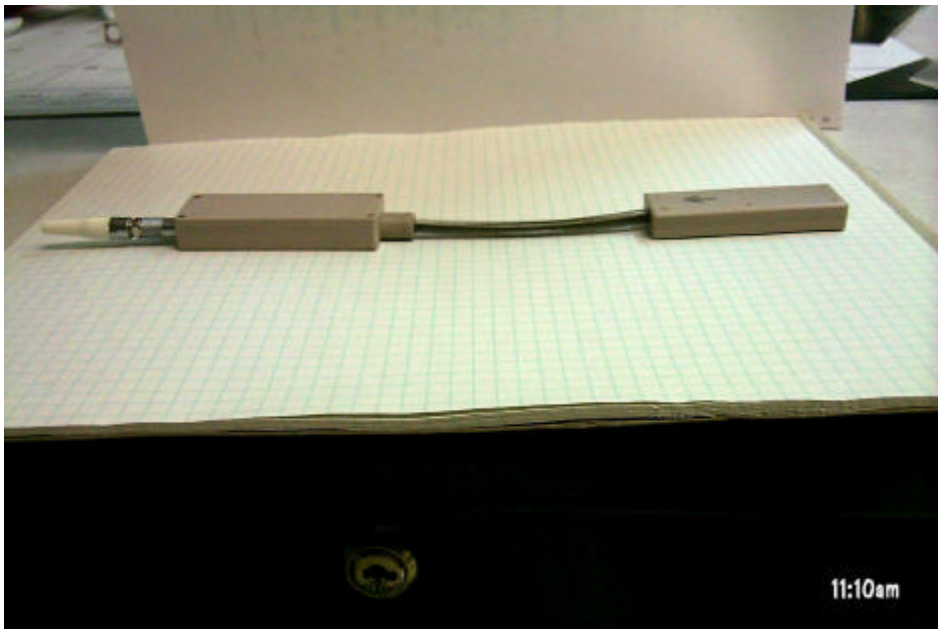
The Joint Excursion System (JES) provides a means for measuring the full range of motion of instrumented joints. The hardware is based on the Biometrics, Ltd. commercial display unit and sensors. The system consists of a display unit, angle sensors and associated cables. The display unit outputs an analog signal that will be acquired using the Ambulatory Data Acquisition System (ADAS).

The JES housing will be manufactured in house at JSC. All other components of the system are being provided as altered items directly from the vendor. For example, the goniometer end blocks have been remanufactured from a flight approved plastic material, Polyethertherketone (PEEK). All of the circuit boards will be conformal coated during final assembly at JSC. The system uses a standard 9v alkaline battery for power.

## 19.1 HARDWARE DESIGN

### 19.1.1 Angle Sensors

The angle sensors, or goniometers, consist of strain gauges that affect the balance of an internal Wheatstone bridge. The amount of change in the Wheatstone bridge is sent to the Angle Display Unit where it is converted to an angle. There are 3 types of angle sensors: one each for the hip, ankle and knee. The sensors are shown in the figure below.




19.1.2 Angle Display Unit

The Angle Display Unit (ADU) is a small electronics box that converts the electrical signal from the angle sensors to an angle. This information is then transferred to the ADAS. There will be one ADU on each leg of the subject. Each ADU can accept 2 signals. The ankle and knee sensor each provide one signal, the hip sensor provides 2 signals because 2 directions of movement are measured on the hip.


JES Angle Display Unit ADU301 – Commercial Unit

## 19.2 OPERATIONS

### 19.2.1 Launch/Ascent and Transport to Station

The JES hardware will be stowed for launch and transferred to ISS upon arrival. No shuttle services are required during transport.

### 19.2.2 On Orbit Operations

The JES sensors will be calibrated prior to use by placing them in the appropriate calibration template (see below). Once the sensor is placed in the template, the ADU is set to zero. The hip, ankle and/or knee sensors are then removed from the template and positioned over the appropriate joint. The sensor(s) are connected to the Angle Display Units via the JES Sensor Cable Assembly. This cable is within the Lower Extremity Monitoring Suit (LEMS) pant assembly, which is Experiment Unique Equipment (EUE) associated with the FOOT

experiment. The ADU is connected to the ADAS for data collection via the LEMS Data Cable Assembly (also EUE).


JES Hip, Knee & Ankle On-Orbit Calibration Templates

19.2.3 Rapid Safing

JES hardware could be easily removed in a rapid safing situation, but egress to an adjacent module would not be prevented while wearing this hardware. No safing is required for the hardware.

19.2.4 Fire Protection

Fire prevention is handled in the design process. The JES hardware is made with approved materials and with proper wire sizing and circuit protection. Elimination of fire sources through conformal coating and electronic parts derating was implemented in the design. Proper grounding is also implemented. Although there is no reason to leave the hardware powered while unattended, fire detection would be handled by the module smoke detector. The ADU, while not sealed, does not have any intentional venting, therefore would be self-extinguishing. If necessary, fire suppression could be accomplished using the Portable Fire Extinguisher (PFE) with the wide area/diffuser nozzle.

19.2.5 Maintenance and calibration

A single 9v alkaline battery will last for at least 300,000 cycles of the sensor or 100 hours. However, it is envisioned that a fresh battery will be used for each collection session. No tools are required to change out the battery. The unit is calibrated, for data accuracy, prior to each data collection session. There is no calibration required as part of a maintenance procedure. The data collection calibration is described in the section 19.2.2.1. No other maintenance is planned or foreseen. The unit would be returned to earth if it malfunctioned.

19.2.6 Aging and disposal

The JES hardware will be designed to operate for 10 years, but would be replaced if it becomes inoperable.

19.3 INTERFACE REQUIREMENTS

No critical services are required from the orbiter or ISS for this hardware item.

### 19.3.1 Crew

The sensors will be positioned on the knee, hip, and/or ankle of the subject. The sensors will be held in place using Experiment Unique Equipment (EUE) such as the Lower Extremity Monitoring Suit (part of the HRF Foot Reaction Forces During Spaceflight experiment). The Angle Display Units will be worn in the thigh or waist area of the subject, also held in place by EUE.

### 19.3.2 Power

Power is supplied to the Angle Display Units via an internal 9V battery. See schematic in figure19.3.2-1.

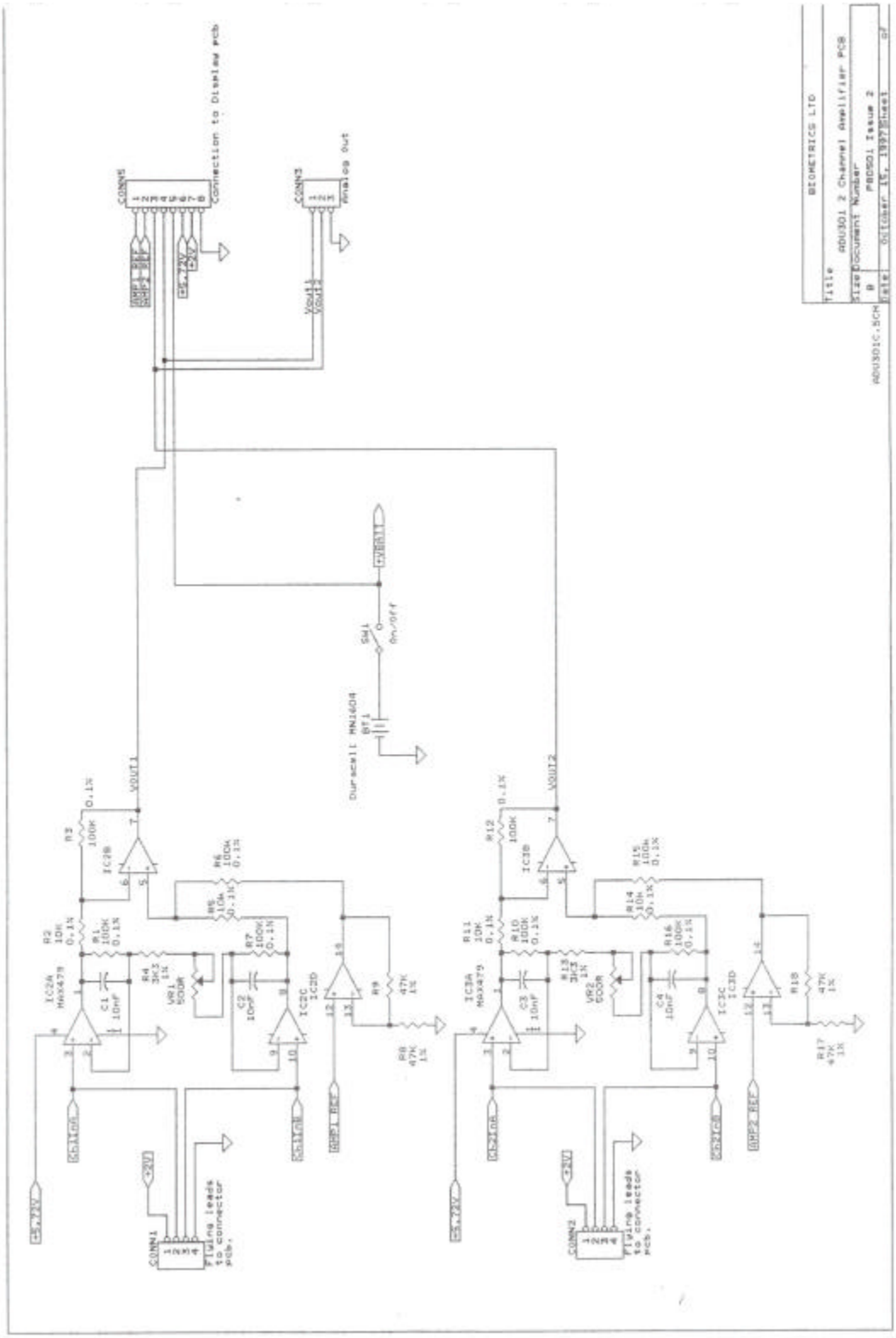

BIOMETRICS LTD
Title
ADU301 2 Channel Amplifier PCB
Size
A
Document Number
PBC301 Issue 2
Date
October 15, 1997
Sheet
of
ADU301C.SCH
Connection to Display pcb
Analog Out
Duracell MN1604
Sw1
On/Off
Wiring leads to connector pcb.
Wiring leads to connector pcb.

Figure 19.3.2-1 Battery Schematic

### 19.3.3 Data

Data is transferred from the Angle Display Units to the ADAS via the LEMS Data Cable Assembly. Data is collected on PCMCIA cards by the ADAS. It can then be transferred to the HRF workstation where data can be downlinked to the ground.

## 19.4 SAFETY ASSESSMENT

Payload safety critical subsystems are normally subdivided into pressure systems, radiation, mechanical, structural, electrical, human factors, and materials categories for consideration. The following categories are applicable to the JES Hardware and are documented on the Form 1230 in Appendix 19A. A list of hazard controls requiring crew procedures or crew training can be found in Appendix 1D at the front of this document.

### 19.4.1 Human Factors

Construction of the JES Hardware will meet the requirements specified in SSP 57000, section 3.12.9.2, for sharp edges, corners, or protrusions. No potential pinch points have been identified.

The JES Hardware will meet touch temperature requirements of letter MA2-95-048, “Thermal Limits for Intravehicular Activity (IVA) Touch Temperature”.

### 19.4.2 Materials

All materials selected for the manufacture and construction of flight hardware and equipment, both metallic and non-metallic, meet the requirements specified in applicable requirements documentation (MSFC-HDBK-527/JSC 09604, “Materials Selection List for Space Hardware Systems”; SSP 30233, “Space Station Requirements for Materials and Processes”; NSTS 1700.7B, “Safety Policy and Requirements for Payloads Using the Space Transportation System”; and NSTS 1700.7 ISS Addendum, “Safety Policy and Requirements for Payloads Using the International Space Station”). JSC/EM2 will review and approve all materials for the JES Hardware and supply the material certification prior to flight.

No toxic materials are used in conjunction with this hardware item.

The LCD and all LED’s are made of non-shatterable materials and are then covered by the membrane keypad.

19.4.3 Electrical

The JES Hardware will be in compliance with SSP 30237, “Space Station Electromagnetic Emission and Susceptibility Requirements”. EMI compatibility testing will be performed.

All electrical connections will be made per procedures with the power to the Angle Display Unit turned off.

19.4.4 Batteries

A commercial alkaline 9V battery is used to provide power for the Angle Display Unit. The battery will follow the guidelines of JSC 20793,

"Manned Space Vehicle Battery Safety Handbook," and will be approved for its intended use by the JSC power systems branch.

19.4.5 Rapid Safing

The JES Hardware will meet the rapid safing requirements of Letter MA2-96-190 and will not impede emergency IVA egress into other pressurized volumes.

19.4.6 Safety Re-verifications

No periodic re-verifications are required to ensure safe operation for the life of this hardware item.

19.4.6 Action Items/Non-compliances/Hardware Anomalies

One action item remains open on the Range of Motion Suit (ROMS), which is being replaced by the Joint Excursion System and the Lower Extremity Monitoring Suit (LEMS).

> "Reconsider the need for an expiration date on the MUA, clarify whether wearing additional garments over the ROMS is required, and evaluate the possibility that an electrical short circuit could provide an ignition source. Update the HR and MUA as appropriate."

This action item will be covered with the "Foot Reaction Forces in Spaceflight" experiment package, which includes the LEMS.
No other action items remain open on this hardware item. No non-compliances have been identified with this hardware. No safety-related anomalies have occurred with this hardware item.

# Appendix 19A

## Standard Hazards
## for the JES Hardware

| FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT | | | A. NUMBER<br>STD- JES | B. PHASE<br>Phase 0/I/II | C. DATE<br>Dec 2000 |
|---|---|---|---|---|---|
| D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*<br>HRF - Joint Excursion System (JES) see attached table for part numbers | | | HAZARD TITLE<br>STANDARD HAZARDS | | E. VEHICLE<br>Shuttle/Station |
| **F. DESCRIPTION OF HAZARD:** | **G. HAZARD CONTROLS:** *(complies with)* | | **H. APP.** | **I. VERIFICATION METHOD, REFERENCE AND STATUS:** | |
| 1. Structural Failure *( payloads must comply with the listed requirements for all phases of flight)* | a) Designed to meet the standard modular locker stowage requirements of NSTS 21000-IDD-MDK or equivalent IDD_____, or<br>b) Stowed in SPACEHAB per MDC91W5023. *Note: Locker and Soft Stowage items only* | | ☒<br>☐ | Reference SSP 50321, International Subrack Interface Standard (ISIS) Drawer Specification, limits for weight and c.g. of ISIS drawer with SSCCD approval. Open, expected closure 4/15/01. | |
| 2. Structural Failure of Sealed or Vented Containers | a) Sealed containers must meet the criteria of NASA-STD-5003, contain a substance which is not a catastrophic hazard if released, be made of conventional metals, and have a maximum delta pressure of 1.5 atm.<br>b) For intentionally vented containers, vents are sized to maintain a 1.4 factor of safety for Shuttle or a 1.5 factor of safety for Station with respect to pressure loads. | | ☐<br>☐ | N/A | |
| 3. Sharp Edges | Meets the intent of one or more of the following:<br>a) NASA-STD-3000 / SSP 50005<br>b) SLP 2104<br>c) NSTS 07700 Vol. XIV App. 7 (EVA hardware)<br>d) NSTS 07700 Vol. XIV App. 9 (IVA hardware) / SSP 57000 | | <br>☐<br>☐<br>☐<br>☒ | Sharp Edge Inspection of as-built hardware. To be closed by TPS. Open, expected closure 4/15/01. | |

| FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT | | A. NUMBER<br>STD- JES | B. PHASE<br>Phase 0/I/II | C. DATE<br>Dec 2000 |
|---|---|---|---|---|
| D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*<br>HRF - Joint Excursion System (JES) see attached table for part numbers | | HAZARD TITLE<br>STANDARD HAZARDS | | E. VEHICLE<br>Shuttle/Station |

| F. DESCRIPTION OF HAZARD: | G. HAZARD CONTROLS: *(complies with)* | H. APP. | I. VERIFICATION METHOD, REFERENCE AND STATUS: |
|---|---|---|---|
| 4. Shatterable Material Release | a) All materials are contained.<br>b) Optical glass (i.e. lenses, filters, etc.) components of crew cabin experiment hardware that are non-stressed (no delta pressure) and have passed both a vibration test at flight levels and a post-test visual inspection.<br>c) Payload bay hardware shatterable material components that weigh less than 0.25 lb and are non-stressed (no delta pressure) or non-structural. | ☐<br>☐<br>☐ | |
| 5. Flammable Materials | a) A-rated materials selected from MAPTIS, or<br>b) Flammability assessment per NSTS 22648 | ☒<br>☐ | Review/approval of material list by JSC/EM2 Material Branch. Open, expected closure 4/15/01. |
| 6. Materials Offgassing | a) Offgassing tests of assembled article per NHB 8060.1 | ☒ | Review/approval of offgas testing by JSC/EM2 Materials Branch. Open, expected closure 4/15/01. |
| 7. Nonionizing Radiation<br>7.1 Non-transmitters | a) Pass NSTS 21288 / SSP 30237 EMI compatibility testing, or<br>b) NSTS/MS2 approved analysis | ☒<br>☐ | Review of test results for successful completion of EMI compatibility testing. To be closed by TPS. Open, expected closure 4/15/01. |
| 7.2 Lasers | a) Beams are totally contained at the maximum possible power and there is no crew access, or<br>b) Meet ANSI Z136.1-1993 for class 1, 2, or 3a Lasers (as measured at the source). | ☐<br>☐ | N/A |

| FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT | | A. NUMBER<br>STD- JES | B. PHASE<br>Phase 0/I/II | C. DATE<br>Dec 2000 |
|---|---|---|---|---|
| D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*<br>HRF - Joint Excursion System (JES) see attached table for part numbers | | HAZARD TITLE<br>STANDARD HAZARDS | | E. VEHICLE<br>Shuttle/Station |

| F. DESCRIPTION OF HAZARD: | G. HAZARD CONTROLS: *(complies with)* | H. APP. | I. VERIFICATION METHOD, REFERENCE AND STATUS: |
|---|---|---|---|
| 8. Battery Failure *(use of this form is limited to small commercial batteries as listed below)*<br><br>8.1 Alkaline-$MnO_2$, Carbon- Zn, or Zn-Air in sizes D or smaller having 6 or fewer cells either all in parallel or all in series (series/parallel combinations require a unique hazard report), no potential charging source, and cells are in a vented compartment.<br><br>8.2 Li-CFx, Li-Iodine, Li-$MnO_2$, Ni-Cd, Ni-MH, or Ag-Zn which have a capacity of 200 mAh or less, and no more than 2 cells per common circuit. | Pass acceptance tests which include open circuit & loaded voltage measurements, visual examination, and leakage check under vacuum (e.g. 6 hours at 0.1 psia). *Note: Above acceptance testing for button cells in Section 8.2 which are soldered to a circuit board in commercial equipment (not applicable to those button cells in a spring-loaded clip) is limited to a functional check of the equipment utilizing the subject battery.* | ☒ | Battery approval and acceptance testing for 1 9V alkaline battery within the Angle Display Unit. Open, expected closure 4/15/01.<br><br>*Note: Application and schematic reviewed and approved by JSC/EP5.* |
| 9. Touch Temperature | a) Meets IVA touch temperature criteria of letter, MA2-95-048.<br><br>b) Meets EVA touch temperature criteria of NSTS 07700 Vol. XIV App. 7. | ☒<br><br>☐ | Test to ensure surfaces do not exceed 49°C. Open, expected closure 4/15/01. |
| 10. Electrical Power Distribution | a) Shuttle payload - Meets all circuit protection requirements of Letter TA-92-038.<br><br>b) Station payload - Meets station interface circuit protection requirements of SSP 57000 and payload circuit protection requirements of Letter TA-92-038. | ☐<br><br>☐ | N/A, no interfaces to ISS power. |
| 11. Ignition of Flammable Atmospheres in Payload Bay | All ignition sources are controlled as required in Letter NS2/81-MO82, and MLI grounded per ICD 2-19001. | ☐ | N/A |
| 12. Rotating Equipment | Rotating equipment meets criteria of NASA-STD-5003 for obvious containment. | ☐ | N/A |

| FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT | A. NUMBER | B. PHASE | C. DATE |
|---|---|---|---|
| | STD- JES | Phase 0/I/II | Dec 2000 |

| D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)* | HAZARD TITLE | E. VEHICLE |
|---|---|---|
| HRF - Joint Excursion System (JES) see attached table for part numbers | STANDARD HAZARDS | Shuttle/Station |

| F. DESCRIPTION OF HAZARD: | G. HAZARD CONTROLS: *(complies with)* | H. APP. | I. VERIFICATION METHOD, REFERENCE AND STATUS: |
|---|---|---|---|
| 13. Mating/demating power connectors | Meets all requirements of Letter MA2-97-093. | ☒ | Review of crew procedures to verify hardware power switches are in the "off" position prior to making connections. Open, expected closure 4/15/01. |
| 14. Contingency Return and Rapid Safing | a) Shuttle payload - Meets all rapid safing requirements of Letter MA2-96-190. | ☐ | Hardware will not impede emergency egress. Removal of equipment from subject can be accomplished in <30 seconds. CLOSED. |
| | b) Station payload - Meets rapid safing requirements of Letter MA2-96-190, and design shall not impede emergency IVA egress to the remaining adjacent pressurized volumes. | ☒ | |

| APPROVAL | PAYLOAD ORGANIZATION | SSP/ISS |
|---|---|---|
| PHASE I | | |
| PHASE II | | |
| PHASE III | | |

| PART NAME | PART NUMBER |
|---|---|
| Angle Display Unit | SEG46117981 |
| Ankle Sensor | XM-110/N |
| Hip Sensor | XM-180/N-S |
| Knee Sensor | XM-180/N |
| Hip and Knee Template | TBD |
| Ankle Template | TBD |